

A NEW SPECIES OF *MOMPHA* HÜBNER
(LEPIDOPTERA: COLEOPHORIDAE: MOMPHINAE) FROM BUTTONBUSH
(*CEPHALANTHUS OCCIDENTALIS* L.) WITH DESCRIPTIONS OF THE
EARLY STAGES

DAVID L. WAGNER, DAVID ADAMSKI, AND RICHARD L. BROWN

(DLW) Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269, U.S.A. (e-mail: dwagner@uconnvm.uconn.edu); (DA) Department of Systematic Biology, Entomology Section, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0168, U.S.A. (e-mail: dadamski@sel.barc.usda.gov); (RLB) Mississippi Entomological Museum, Box 9775, Mississippi State, MS 39762, U.S.A.

Abstract.—*Mompha solomoni*, n. sp., is described from moths reared from buttonbush, *Cephalanthus occidentalis* L. (Rubiaceae). Spring generations bore in young terminals of this plant species; summer and fall generations mine leaves. The egg, larval, pupal, and adult stages of the new species are described and illustrated. *Mompha solomoni* appears to be related to other Rubiaceae-feeding momphines, including the previously described and widely distributed *Mompha cephalonthiella* (Chambers), which also feeds on buttonbush. Life history data are provided for both of these *Cephalanthus*-feeding momphines. Parasites of *Mompha solomoni* include members of the genera *Pholetesor* Mason (Braconidae), *Bracon* F. (Braconidae), and *Euderus* Haliday (Eulophidae).

Key Words: leafmining, stem-mining, flagging, Rubiaceae

In North America the Momphinae contain 37 described species and at least as many unrecognized species (Hodges et al. 1983, Hodges 1992, Poole and Gentili 1996, Koster 2002). While all momphines in North America are thought to share the habit of being internal feeders, larvae show a remarkably diverse range of feeding niches—tunneling in stems, forming galls, mining leaves, and boring through flowers and fruits. Larvae of the species described here feed in young shoots, killing the terminal portion in spring and early summer broods, but in subsequent broods the larvae mine leaves. Because *Mompha solomoni* appears to be related to a second buttonbush-leaf-miner, *Mompha cephalonthiella* (Chambers), we include considerable information on this species as well.

Preparations of all life stages were examined with dissecting, compound, and scanning electron microscopes. *The Methuen Handbook of Colour* (Kornerup and Wanscher 1978) was used as a color standard for the description of the adult. Genitalia were dissected as described by Clarke (1941), except that mercurochrome and chlorazol black were used as stains. All measurements were made with a calibrated ocular micrometer.

Ultrastructural studies were performed with a Hitachi HH-S-2R scanning electron microscope at an accelerating voltage of 20kV. For SEM examination, immature specimens were fixed in 3% glutaraldehyde in 0.1M potassium phosphate buffer (pH 7.3), rinsed in phosphate buffer (pH 7.3),

and postfixed in 2% osmium tetroxide in 0.1M potassium phosphate (pH 7.3). After dehydration in ethyl alcohol, specimens were critical point dried, mounted on stubs with silver paint and paste, and coated with gold-palladium.

Life history data for both *Mompha* species were obtained from laboratory rearings at ambient temperatures. James D. Solomon studied a population of the new *Mompha* species in the Delta Experimental Forest in Stoneville, Washington Co., MS. Casual observations were made on the population beginning in 1980. In 1986, collections of 10–20 shoots were made once or twice weekly in April, May, and June. Half of these were dissected to monitor larval development; larvae in the other half of the shoots were held in plastic Petri dishes over filter paper in ventilated jars to study pupation habits, parasitoids, and adult emergence. Additional collections were made by James Solomon in 1987 and 1988, mostly in the Delta National Forest, Issaquena and Sharkey cos., MS, but a few additional samples were secured from Chicot Co., AR, and East Carroll Parish, LA.

Leafmines of *Mompha cephalonhiella* were taken at Nicholas along the Feather River, Sutter Co., CA, in September 1981 (DLW Lot: 81J6) and October 1982 (DLW Lot: 82K5); from along the American River, 4.8 km E of Auburn, El Dorado Co., CA, in September 1982 (DLW Lot: 82J12); Mansfield, Tolland Co., CT (DLW Lot: 89H49) in August 1989; and Sand Bar State Park, Chittenden Co., VT, in June 1987 (DLW Lot: 87F59). Collections of *Mompha solomoni* were made from Tolland and Windham cos., CT, in August, September, and October 1989 (DLW Lots: 89H49, 89J6, 89J14, 89K37, and 89K62); Monroe Co., FL in March, 1991 (DLW Lot: 91C14); Anne Arundel Co., MD, August 2002 (DLW Lot: 2002H28); and from Oak Point, Hammond, Saint Lawrence Co., NY, in August 1988 (DLW Lot: 88H45). In each case, leaves with actively feeding larvae were placed in a plastic bag with lightly

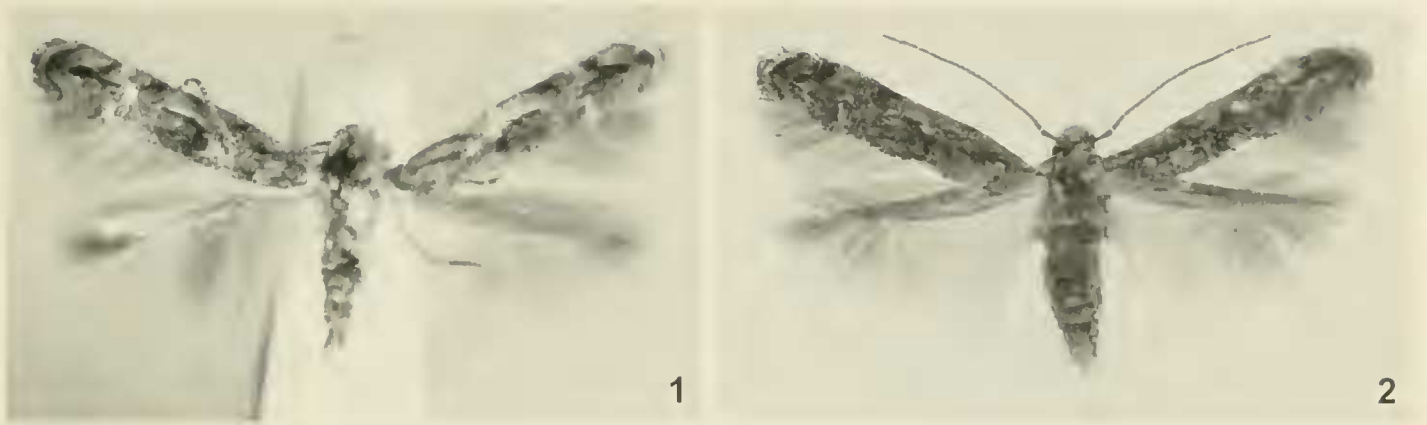
moistened paper toweling and were monitored daily for adult emergences. Rearing lots were held outdoors during the winter months. Larvae and pupae for subsequent study were killed in boiling water and transferred to 70% ethyl alcohol.

Specimen repositories are as follows: BL = private collection of Bernard Landry, Genève, Switzerland; CNC = Canadian National Collection, Ottawa; ECK = private collection of Edward C. Knudson, Houston, TX; GB = private collection of George Balogh, Portage, MI; INHS = Illinois Natural History Survey, Champaign; JRW = private collection of James R. Wiker, Athens, IL; MEM = Mississippi Entomological Museum, Mississippi State; SK = private collection of Sjaak Koster, Leiden, Netherlands; UCONN = University of Connecticut Insect Collection, Storrs; USNM = National Museum of Natural History, Smithsonian Institution, Washington DC. In the material examined a "u" indicates a specimen could not be reliably sexed.

***Mompha solomoni* Wagner, Adamski,
and Brown, new species**

(Figs. 1, 3, 4, 7, 9–18, 20–40, 43–46, 49)

Diagnosis.—In the discal area of the forewing, *M. solomoni* (Fig. 1) possesses an elongate black dash that is usually joined with a white dash along its anterior margin; neither marking is well developed in *M. cephalonhiella* (Fig. 2). The forewing of *M. cephalonhiella* is usually suffused with appreciably more coffee-brown and steely blue scales than that of *M. solomoni*. In *M. solomoni* the dark spot along forewing costa at $\frac{2}{3}$ is often strongly oblique and directed toward the outer edge of the wing or tornus; in *M. cephalonhiella* this mark is often less oblique and directed toward the tornus or inner margin. Between the dark costal spots at $\frac{2}{3}$ and $\frac{3}{4}$, *M. cephalonhiella* has a patch of tan scales; this area is mostly gray or brown in *M. solomoni*. In *M. cephalonhiella* the 1 or 2 white flagellomeres that cap the antenna are preceded by a series of five dark flagellomeres; in *M. solo-*



Figs. 1–2. Adults: 1, *Mompha solomoni*. 2, *M. cephalonhiella*.

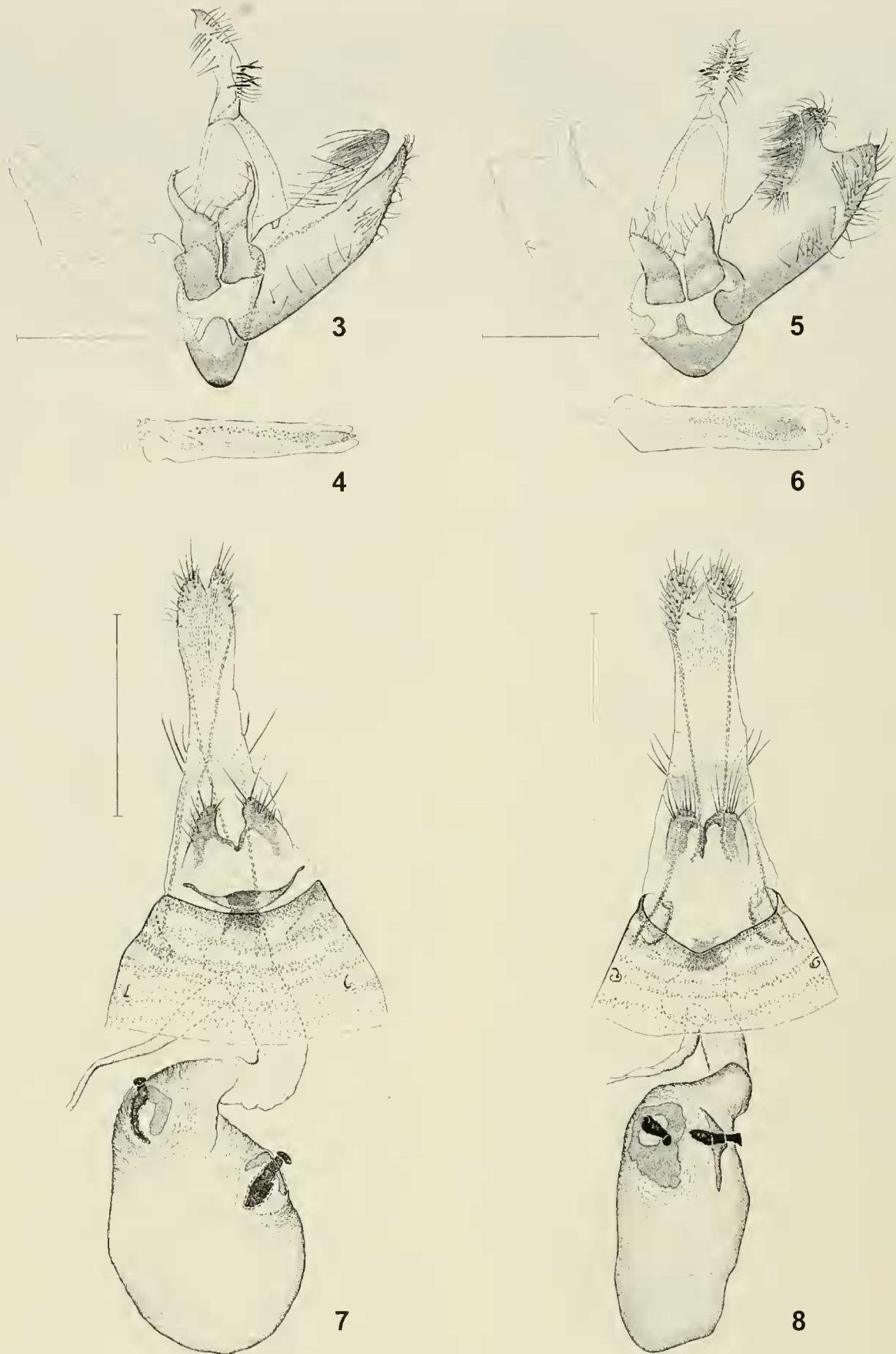
moni an additional pale ring interrupts the preapical run of dark flagellomeres.

Genitalia of the two species (Figs. 3–8) are very different in both sexes. In male *M. solomoni* (Fig. 3) the anellus has distolateral, curved arms (that are absent in *M. cephalonhiella*) (Fig. 5); the ventral margin of the valva is entire (notched in *M. cephalonhiella*); and the sacculus is narrow and acuminate (wide and erose in *M. cephalonhiella*). In female *M. solomoni* (Fig. 7), the invaginated pockets at the posterolateral corners of tergum VII are much less prominent than in *M. cephalonhiella* (Fig. 8); also, in *M. solomoni*, the posterior projections of the lamella postvaginalis are subtriangular, separated by a deep, V-shaped cleft, and preceded by a short, spinose thickening located medially at the anterior end of the cleft (projections rounded, separated by a shallow cleft, and preceded by a long, sclerotized thickening at the anterior end of cleft in *M. cephalonhiella*); furthermore, both of the sclerotized plates associated with the signa are small and crescent shaped in *M. solomoni* (one or both of the plates are large and round and completely surround the signum in *M. cephalonhiella*); and finally, a lamella antevaginalis is present in *M. solomoni*, but absent in *M. cephalonhiella*. The mandibular setae of the larvae differ: in *M. solomoni* the setae are of unequal length (Fig. 18), whereas those of *M. cephalonhiella* are of similar length (Fig. 19).

Description.—*Head*: Base of proboscis

and frons shiny white, vertex yellowish white, becoming gray to brownish gray posteriorly on occiput, a line of sparse brown scales extend from middle of eye anteriorly to base of antenna, brown scales becoming dense and covering dorsal surface of scape; distal portion of antenna with six white rings of one flagellomere each, each white ring separated by three brown flagellomeres, except terminal two rings separated by two brown flagellomeres; labial palpus with first segment and medial surface of second segment white, lateral surface of second segment brown basally, intermixed with variable number of white scales apically, third segment brown, intermixed with white scales, with indistinct white bands at middle and apex.

Thorax: Mesonotum and tegula dark brownish gray, some scales with gray tips, tegula with apex gray to orange gray; foreleg with femur laterally brownish gray basally, white to gray apically, medially white except for brownish-gray posterior margin, tibia laterally dark brownish gray, medially dark brownish gray on margins, white in middle, tarsomeres laterally dark brownish gray with white apices, medially white mixed with scattered brownish-gray scales; midleg with femur white except for scattered dark brownish-gray scales on posterolateral margin, tibia laterally dark brownish gray intermixed with white to form diagonal bands at base, middle, and apex, tarsomeres dark brownish gray laterally, first, second, fourth, and fifth tarsomeres with



Figs. 3–8. Male and female genitalia. 3, *Mompha solomoni* male. 4, *M. solomoni* aedeagus. 5, *M. cephalonthiella* male. 6, *M. cephalonthiella* aedeagus. 7, *M. solomoni* female. 8, *M. cephalonthiella* female.

white apices; hindleg with femur white, tibia dark brownish gray with broad white diagonal bands of setiform scales near base, middle, and apex, tarsus dark brownish

gray with tarsomere 5 and apices of tarsomeres 1–4 white. Forewing (Fig. 1): Length: 3–3.9 mm (16 males), 2.7–3.8 mm (13 females); ground color dark gray to

brownish gray, scales with white apices except on basal $\frac{1}{3}$ of costa; scale tufts at $\frac{1}{3}$ and $\frac{3}{4}$, each with 5–6 rows of erect scales, basal tuft dark brown, outer tuft white basally, dark brown apically, line of sparse dark brown scales extending apically for short distance from middle of basal tuft, line of dense dark brown scales extending along Rs from anteroapical corner of each tuft, basal radial line bordered by narrow white to orange white line on costal side; costa with dark brown strigulae at about $\frac{1}{3}$, $\frac{2}{3}$, and $\frac{3}{4}$; apical strigula connecting with apical radial line near its midlength, areas between basal radial line and dorsum and on each side of apical radial line suffused with light brown, small white spot posterior to end of apical radial line; dark brown apical strigula, radial line, and apical margin of pale brown spot forming acutely angled indistinct patch contrasting with band of gray scales with white tips on apical end of wing; margin of wing membrane with line of dark brown scales, expanded to form a spot opposite apical end of radial line in some specimens; apical fringe scales with long white bases from apex to midwing, pale gray from midwing to tornus. Under-side dark grayish brown, some specimens with white near midwing. Hindwing: Uniformly grayish brown on both surfaces.

Abdomen: Grayish brown dorsally, white to orange white ventrally.

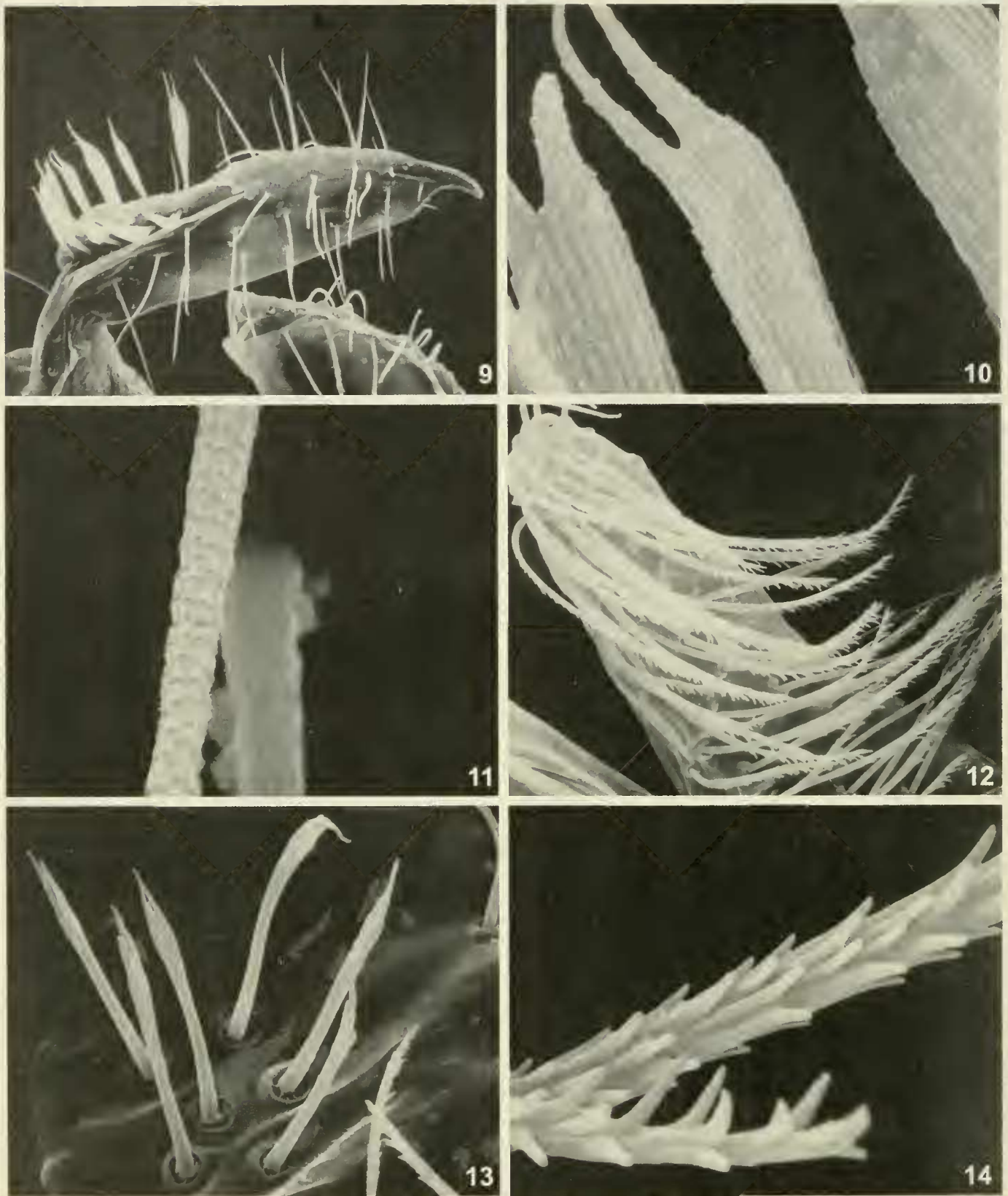
Male genitalia (Fig. 3, 4, 9–14): Uncus separated from tegumen by membranous line, dorsally rounded at base, ventrally and apically flattened, apex acuminate, laterally with flattened setae at base (Figs. 9–10); anellus divided into two flat plates with curved apicolateral arms; aedeagus tubular with subparallel sides, cornuti absent (Fig. 4); valva (Figs. 3, 12–14) apically cleft for $\frac{1}{3}$ length of costa, apex rounded in dorsal division, acute in ventral division (sacculus), costa lightly sclerotized, densely setose apically, sacculus folded dorsally for $\frac{2}{3}$ length of valva, fold narrowed apically, apical third of ventral division more heavily sclerotized than basal $\frac{2}{3}$, sacculus and api-

cal third of ventral division sparsely setose (five preparations examined).

Female genitalia (Fig. 7): Tergum VIII weakly sclerotized with line of sparse setae on posterior margin; papillae anales facing laterally, sparsely setose; lamella postvaginalis with two subtriangular projections separated posteriorly by V-shaped cleft, anterior end of the cleft with a small dentate projection, lamella antevaginalis forming projecting rim over ostium bursae; ductus bursae heavily sclerotized near ostium bursae; corpus bursae with two bladelike signa connected to crescent-shaped plates (four preparations examined).

Holotype.—♂, Miss[issippi], Washington Co., Stoneville, May 1987, J. D. Solomon, *ex Cephalanthus occidentalis*, twig borer. Data are given as on labels except for bracketed information. Deposited in USNM.

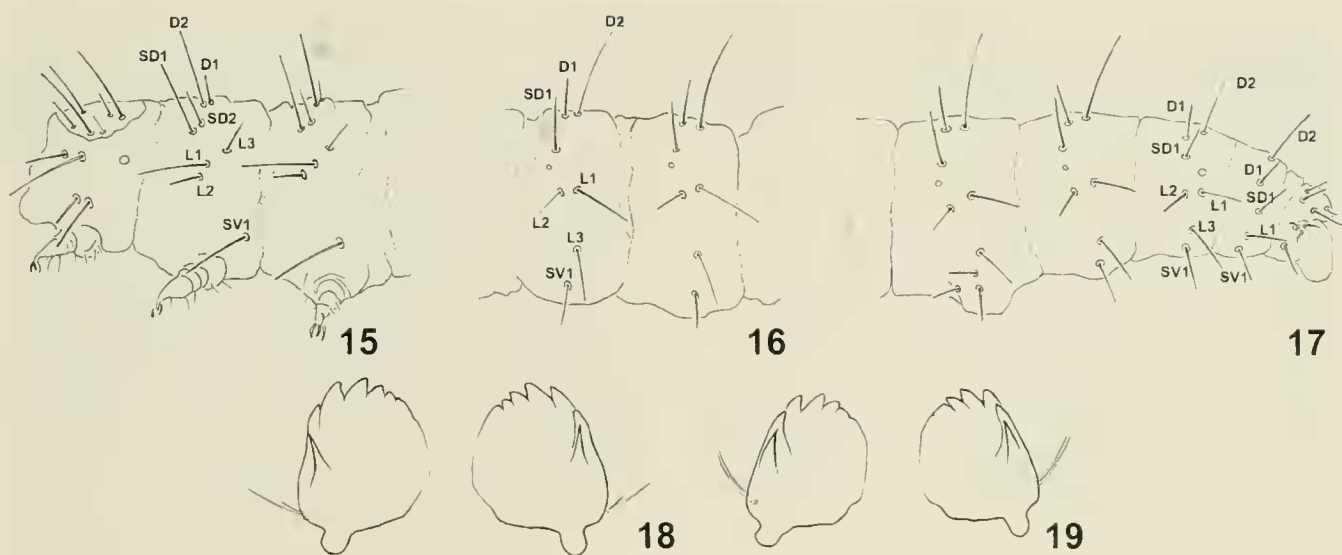
Paratypes (n = 157).—CANADA: QUÉBEC: Gatineau, Aylmer, 18 rue Washington, 30–31 May 1994 (1 ♂), 20–24 Jun. 1994 (1 ♂, 1 ♀), 10–11 Jul. 1994 (1 ♂), B. Landry, at mercury vapor light (BL, SK). UNITED STATES: CONNECTICUT: Windham Co., Chaplin, 0.3 mi. S jct Hwys 6 and 198, 25 Jul. 1992, D. L. Wagner (1 ♀) (UCONN), Hampton, Rock Springs, mines 3 Sep. 1989, adults issued 18 Sep.–21 Oct. 1989, DLW Lot: 89J6, V. R. and D. L. Wagner (7 ♂, 9 ♀, 1 u) (UCONN, ECK), Thompson, Quaddick Reservoir St. Pk., mines 4 Sep. 1989, adults issued 5 Mar.–4 May 1990, DLW Lot: 89J14, D. L. Wagner (9 ♂, 9 ♀, 1 u) (UCONN). DISTRICT of COLUMBIA: Jun. 1902, A. Busck (1 ♂) (USNM). FLORIDA: Highlands Co., Lake Placid, Archbold Biol. Station, 16–22 May 1964, R. W. Hodges (2 u) (USNM); Monroe Co., Big Cypress Natl. Park, Loop Road, vicinity Interport Center, mines 13 Mar. 1991, adults issued 4–19 Apr. 1991, DLW Lot: 91C14, D. L. Wagner, D. R. Davis, and T. Dickel (3 ♂, 1 ♀) (UCONN), mines 11 Apr. 1998, D. R. Davis (4 ♂, 5 ♀) (USNM), Everglades Natl. Park, Anhinga Trail, mines 12 Apr. 1998,



Figs. 9–14. Male genitalia of *Mompha solomoni*. 9, Uncus, lateral (ca. $\times 550$). 10, Squamiform setae of uncus (ca. $\times 4500$). 11, Piliform setae of uncus (ca. $\times 10,000$). 12, Plumose setae over medial surface of valva (ca. $\times 1,000$). 13, Scale cluster over proximomedial surface of valva (ca. $\times 1500$). 14, Detail of plumose setae in Fig. 12 (ca. $\times 6,000$).

D. R. Davis (6 ♂, 11 ♀, 1 u) (USNM). ILLINOIS: Clark Co., Rocky Branch Preserve, 3 July 1995, T. Harrison, coll. as adult at UV light (1 ♀) (INHS); Coles Co., Lake View Park, T12N, R9E, NW $\frac{1}{4}$ Sec.

24, 6 Jul. 1996, T. Harrison, coll. as adult at UV light (1 ♂) (INHS), 21 Jun. 1997, T. Harrison, coll. as adult at UV light (1 ♀) (INHS); Mason Co., 1.5 mi. west of Topeka along C & IM RR in wetland, T22N, R8W,



Figs. 15–19. Larvae of *Mompha solomoni*, ventral setae not shown. 15, T1–T3 of *M. solomoni*. 16, A1–A2 of *Mompha solomoni*. 17, A6–A10 of *M. solomoni*. 18, *M. solomoni* mandibles. 19, *M. cephalonthiella* mandibles.

Sec. 25, J. R. Wiker, larvae boring in stem tip of *Cephalanthus occidentalis*, 25 May 1995, emerged: 11 Jun. 1995 (2 ♂, 2 ♀) (JRW); Union Co., LaRue Pine Hills, 15 Jul. 1995, T. Harrison and J. Wiker, Iss. 29 Aug. 1995, coll. as larva in leaf mine on *Cephalanthus occidentalis* (2 ♀) (INHS). LOUISIANA: Bossier Parish, Barksdale A.F.B., 32°31'13"N 93°35'46"W, 21 May 1996, R. L. Brown and D. Pollock, blacklight in calcareous prairie (1 ♂) (MEM), same data except 32°29'19"N 93°35'20"W, R. L. Brown, blacklight in calcareous forest (1 ♀) (MEM). MARYLAND: "5/8 84," (1 u) (USNM), "30/[?]7 84" (1 ♂, genitalia slide, SBA, USNM 5325) (USNM). MASSACHUSETTS: Barnstable Co., Barnstable, 26 Jun. 1972, C. P. Kimball (1 ♂) (USNM). MICHIGAN: Allegan Co., Allegan State Game Area, 2 Jul. 1992, J.-F. and B. Landry, at mercury vapor light (1 ♂, 2 ♀) (CNC); Clinton Co., Bath, 9 May 1957, R. W. Hodges (1 ♂) (USNM), 1 May 1957, R. W. Hodges (1 ♀, 1 u) (USNM); Kalamazoo Co., Portage, 10 Sep. 1995, G. Balogh, coll. as larva in leaf mine on *Cephalanthus occidentalis*, Iss. 2 Mar. 1996 (7 ♂, 7 ♀) (ECK, GB, INHS). MISSISSIPPI: Franklin Co., Trib. of McGehee Ck., T6N, R4E, Sec. 26SW, 1 Jun. 1992, T. Schiefer, R. Fontenot (1 ♂, 1 ♀), 27 Jul. 1992, R. L.

Brown (1 ♀, genitalia slide TH-MEM 17) (MEM), Porter Creek, T5N, R4E, Sec. 8NW, 1 Jun. 1992, T. Schiefer and R. Fontenot (1 ♂) (MEM); Lowndes Co., 33°18'01"N 88°36'38"W, Black Belt Prairie, 31 May 1994, D. M. Pollock, blacklight in oak-hickory forest (1 ♂) (MEM), same data except T17N, R16E, Sec. 34, 24 Aug. 1993, R. L. Brown and D. Pollock (1 ♀, genitalia slide TH-MEM 16) (MEM); Smith Co., 1 mi N Raleigh, 14–15 Jun. 1985, R. L. Brown and G. Burrows (1 ♀) (MEM); Washington Co., same data as holotype (10 ♂, 8 ♀, genitalia slides male MEM 491, female MEM 492) (MEM), same data except 5 May 1986 (1 ♀) (MEM), 6 May 1986 (3 ♂, genitalia slide MEM 473) (MEM), 8 May 1986 (1 ♂), 9 May 1986 (1 ♀, genitalia slide MEM 320) (MEM), 10 May 1986 (2 ♂) (MEM), 11 May 1986 (1 ♀) (MEM), 14 May 1986 (1 ♂) (MEM), 15 May 1986 (1 ♂) (MEM); Winston Co., Tombigbee Nat. Forest, 33°19'20"N 89°03'55"W, 25 May 1999, R. L. Brown (1 ♂), 15 Jul. 1999, R. L. Brown and J. MacGown (1 ♀) (MEM), 13 Sep. 1999, J. A. MacGown (1 ♀) (MEM). NEW YORK: St. Lawrence Co., Hammond, Oak Point, mines 12–17 Aug. 1988, adults issued 7–11 Apr. 1989, DLW Lot: 88H45, D. L. Wagner (2 ♂, 2 ♀) (UCONN). SOUTH

CAROLINA: Charleston Co., McClellanville, The Wedge, 22 Mar. 1968, R. W. Hodges (1 ♀) (USNM). VIRGINIA: Falls Church, 1924 (1 ♀, genitalia slide, SBA, USNM 5302) (USNM). TEXAS: Jasper Co., Martin Dies State Park, E. C. Knudson 8 May 1986 (2 ♂, one genitalia slide TH-ECK-18), 14 Nov. 1985 (1 ♂, genitalia slide ECK-1275); San Jacinto Co., Sam Houston National Forest, Coldspring, 1 May 1988 (1 ♂, genitalia slide TH-ECK-17).

Other material examined.—UNITED STATES: OHIO: Hamilton Co., Cincinnati, Ferris Woods, mines 14 Sep. 1912, B. 134, A. Braun (3 ♂, 1 ♀, 1 u) (USNM).

Distribution.—*Mompha solomoni* has been found from Illinois, Michigan, southern Québec south to Florida and Texas (Fig. 51).

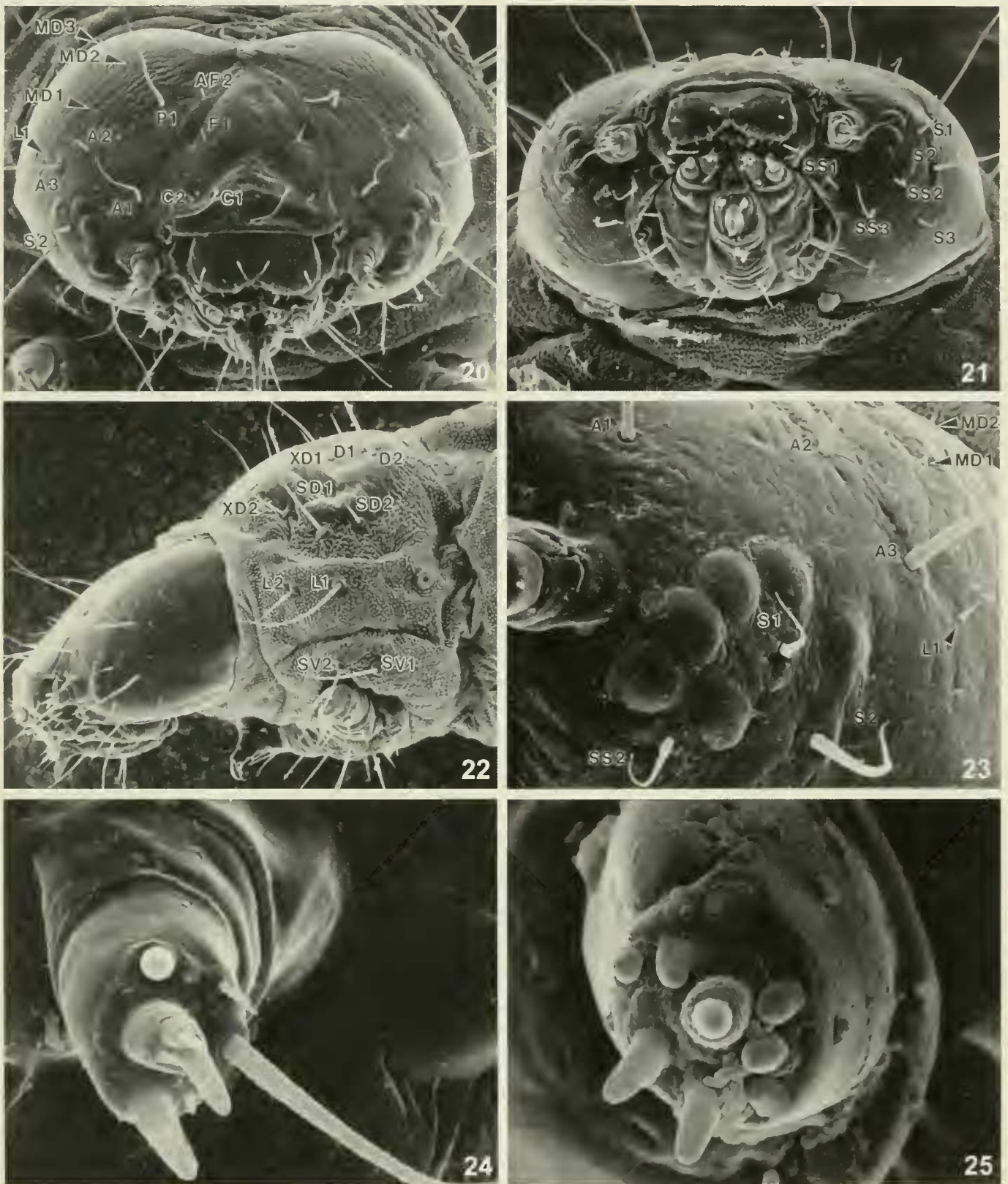
Etymology.—*Mompha solomoni* is named for James D. Solomon, an entomologist retired from the US Forest Service Southern Hardwoods Laboratory in Stoneville, MS, who first brought our attention to this species.

Egg (Figs. 45, 46).—Size 0.13–0.17 × 0.22–0.29 mm (n = 5). Glassy, iridescent, oval to round and somewhat flattened, with small nipplelike projection to one side from which numerous small ridges radiate.

Larva (Figs. 15–18, 20–31).—Length 3.8–5.6 mm (n = 8). Body cream, with slightly raised dome-shaped spinules; thoracic legs and pinacula not strongly pigmented. *Head* (Figs. 20–26): Hypognathous; generally smooth, with some shallow ridges; frons wide, AF1 not observed, F1 and AF2 short, C1 much longer than C2 long; labrum shallowly notched; P1, A3, and S2 about equal in length, longest setae on head; A2 slightly longer than adfrontal setae, A1 intermediate in length; L1 posterior to A3, short; three mid-dorsal setae very reduced; six stemmata arranged in a C-shaped configuration (Fig. 23); antenna as in Fig. 24; mandible (Fig. 18) broad, with several rounded dentitions; two unequal setae on outer surface; labium (Figs.

21, 26) with two-segmented palpus, spinneret parallel sided; maxilla prominent (Fig. 25). *Prothorax* (Figs. 15, 22): L-group bisetose, L2 and L1 in straight line parallel to median longitudinal axis; L1 about twice length of L2; shield with SD1 3–4 times longer than XD2 and SD2; SD2 posterior to SD1; XD1 about $\frac{3}{4}$ length of SD1; D2 about 4 times length of D1; T2 and T3 with D2 about 2–3 times longer than D1, D2 in vertical line with SD2; SD1 about 2 $\frac{1}{2}$ times length of SD2; L2 and L3 subequal in length, L1 about two times longer than L2 and L3; SV1 slightly posterior to L3; all thoracic legs with a pair of broad bladelike setae ventrolaterad of terminal claw (Fig. 27). *Abdomen* (Figs. 16, 17, 28, 30, 31): Prolegs on A3–A6 and A10 of equal size; crochets in a circle, uniserial and uniordinal (Fig. 29); A1–A7 with D2 about 2–2.5 times longer than D1; SD1 slightly anterior to D1, SD1 above spiracle; L2 posterior of SD1, L1 about 2.5 times length of L2; L3 subequal to L1; A3–A6 with SV-group trisetose; SV-group unisetose on A1–A2 and A7–A10; A8 with L-group trisetose, L1, L3, SV1, and V1 roughly in line; A9 with 6 setae, all setae in line; A10 with SD1 about twice the length of SD2 and about three times the length of D1 and D2; L-group trisetose.

Pupa (Figs. 32–40).—Elongate oval in dorsal and ventral view, widest and slightly depressed dorsally in thoracic region; epicranial suture present; anterior tentorial pits visible (Figs. 33, 35); frontoclypeal suture absent and mandibular and/or piliferal area demarcated as a subovate disk (Figs. 33, 35); caudal portion of antennae adjacent on meson, not separating distally to expose metathoracic legs as in most other Gelechioidea (Mosher 1916); axillary tubercle (= mesothoracic spiracle) covered with honeycomb latticework (Fig. 36); midabdominal segments with mediolateral excavations (Figs. 32, 37, 38); cremaster with one pair of dorsal setae and three pairs of ventrolateral setae (Figs. 39, 40).

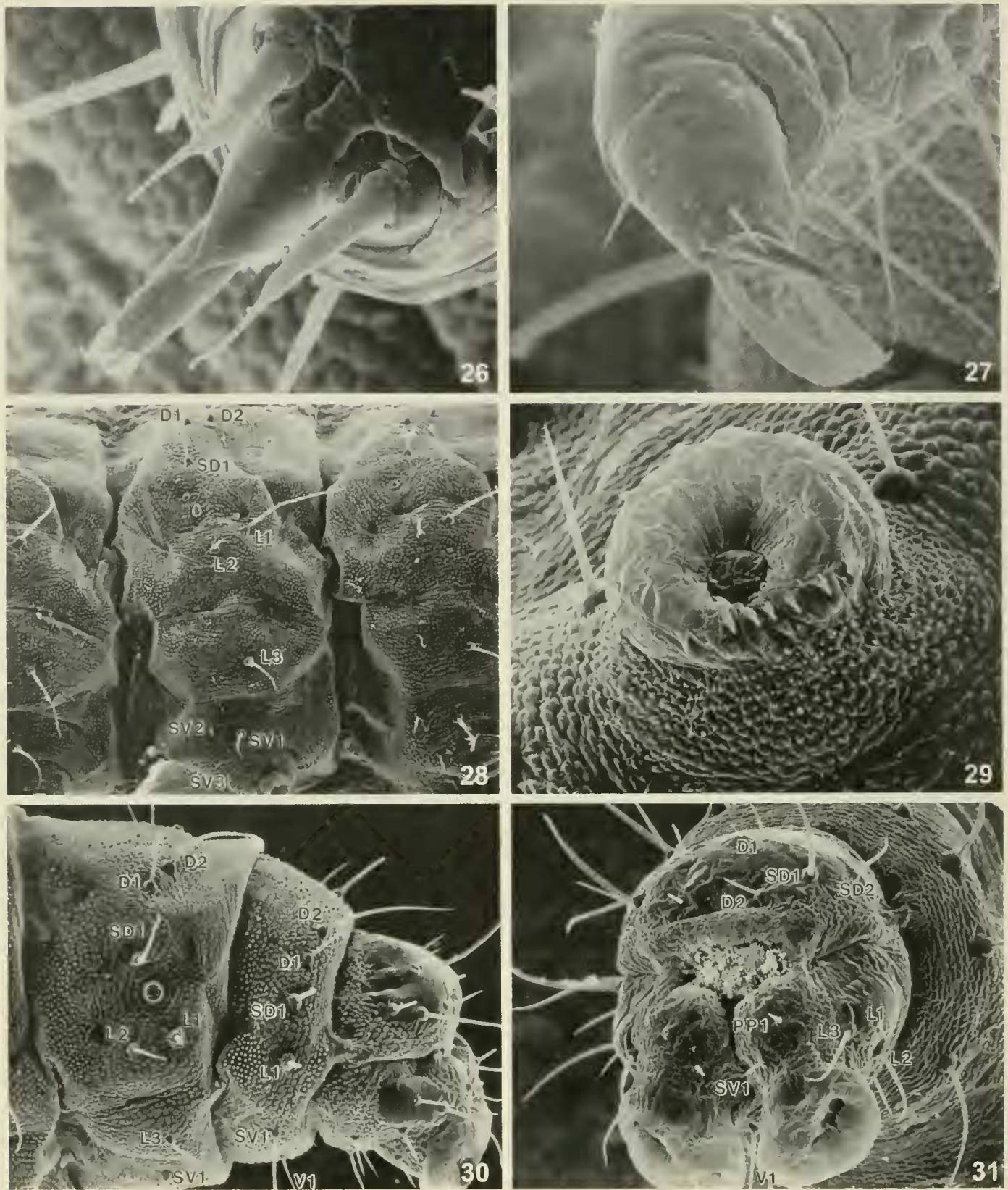


Figs. 20–25. Larval head and prothorax of *Mompha solomoni*. 20, Head, dorsofrontal (ca. $\times 200$). 21, Head, ventrofrontal (ca. $\times 200$). 22, Head and prothorax, lateral (ca. $\times 150$). 23, Stemmatal area (ca. $\times 550$). 24, Antenna (ca. $\times 1700$). 25, Maxilla (ca. $\times 6500$).

BIOLOGY

Although the new species of *Mompha* was initially identified as *M. cephalonhiella*, differences in the biologies between these two *Cephalanthus*-feeding momphines suggested otherwise. *Mompha solomoni*

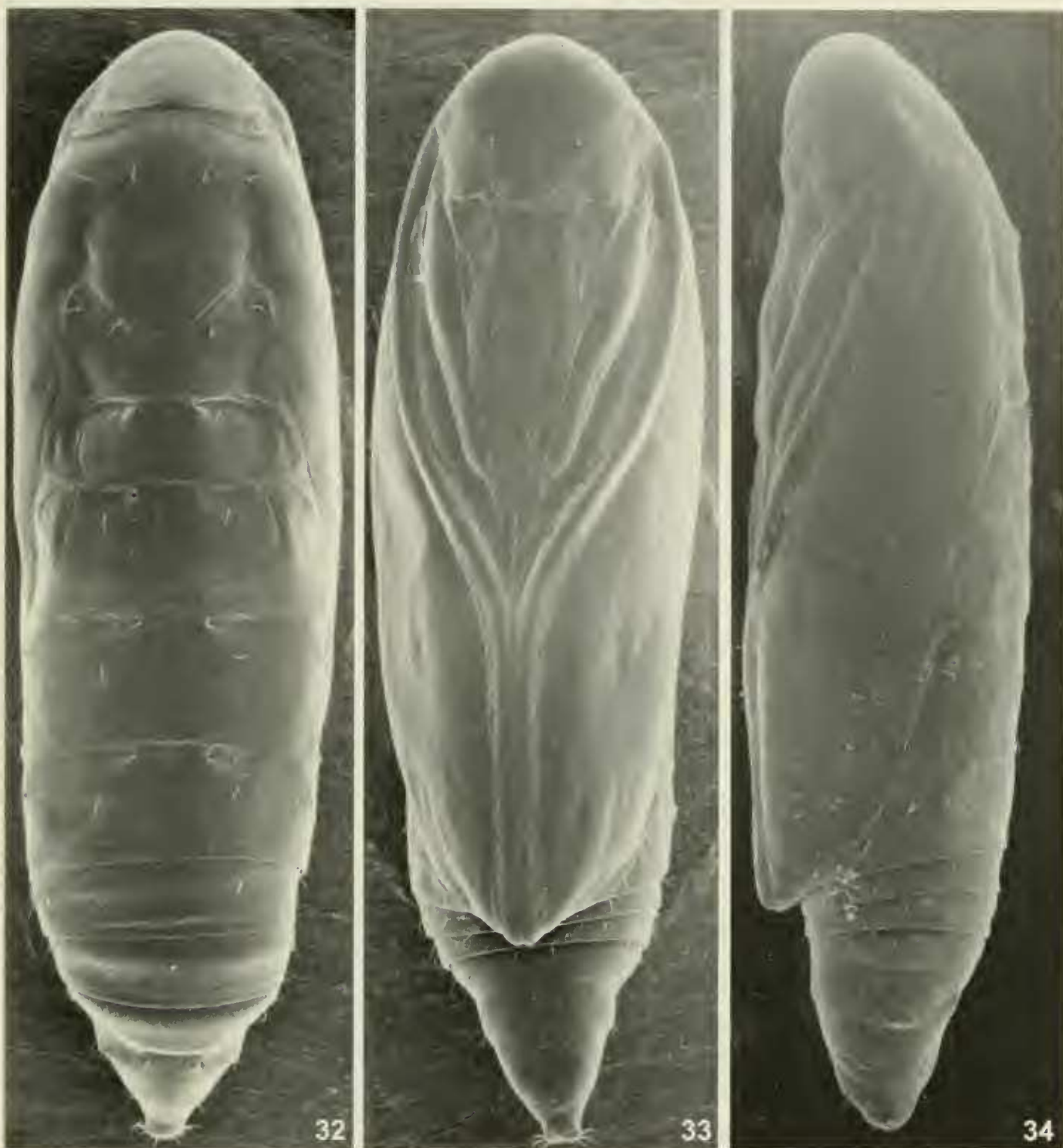
is a borer in young shoots of *Cephalanthus occidentalis* early in the growing season but later switches to leafmining. *M. cephalonhiella* is believed only to mine leaves of *C. occidentalis*. The life histories of the two species, as far as known, are given below.



Figs. 26–31. Larva of *Mompha solomoni*. 26, Maxillolabial complex (ca. $\times 1500$). 27, Thoracic claw (ca. $\times 650$). 28, A3–A6 (ca. $\times 95$). 29, Abdominal proleg (ca. $\times 500$). 30, A8–A10 (ca. $\times 150$). 31, A10 (ca. $\times 200$).

Shoot-mining broods of *Mompha solomoni*.—Early instar larvae tunnel in new shoots below the shoot apex in the first week of April in MS. Only tender, succulent new growth is utilized. The larval tunnel meanders about the shoot axis, eventually killing the new growth. Initially, the

larva may proceed upward to the meristem, but eventually the tunnel is directed toward the base of the new shoot, where the stem is hollowed out and filled with dark brown frass (Fig. 43). Gallery lengths range from 15 to 55 mm ($n = 60$). Of 100+ dissected shoots, about 90% were occupied by a sin-



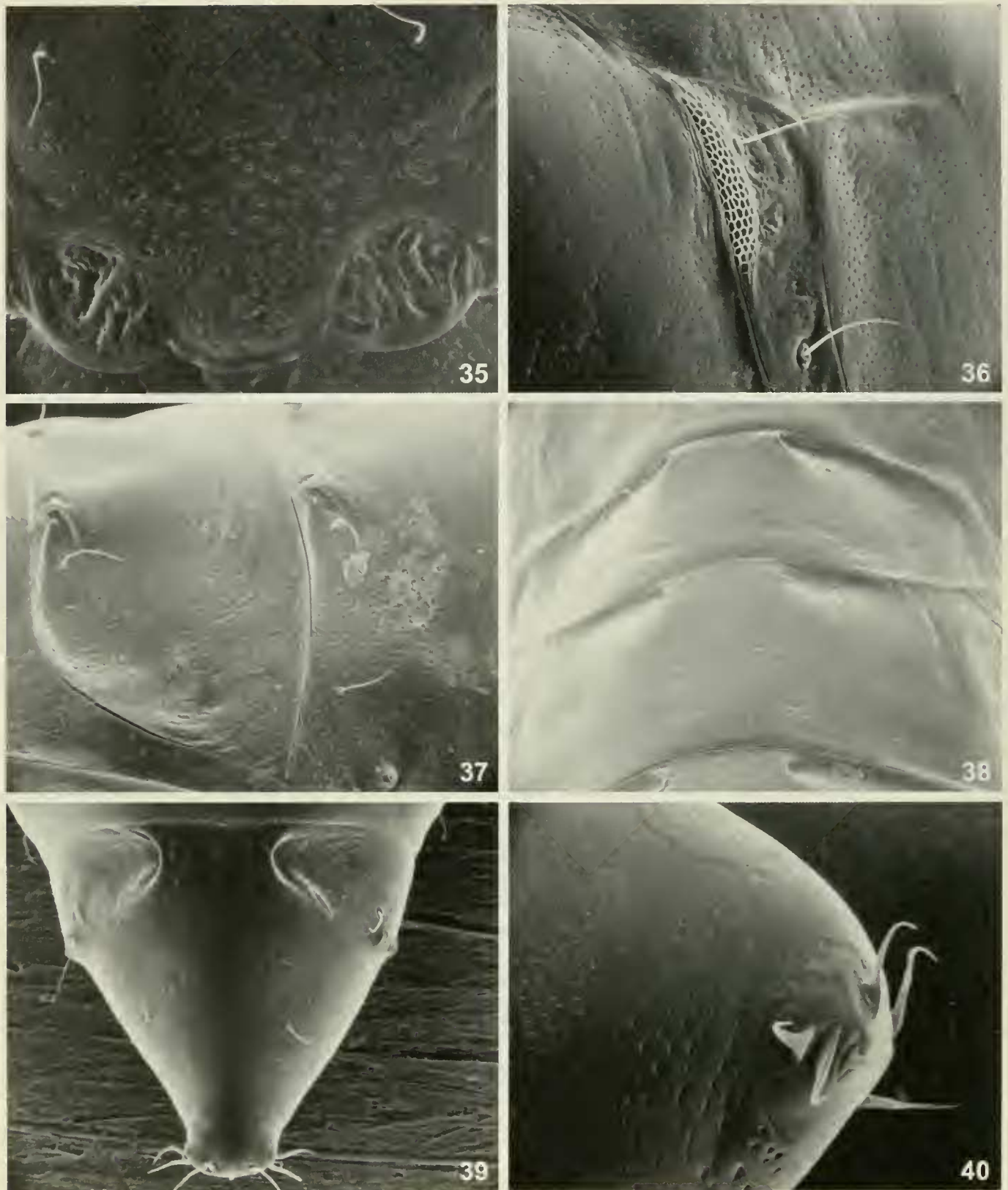
Figs. 32–34. Pupa of *Mompha solomoni* (montages at ca. $\times 65$). 32, Dorsal. 33, Ventral. 34, Lateral.

gle larva, the remaining shoots by two larvae; exit holes (Fig. 42) on a few shoots suggest that as many as three larvae mature in a single twig. Prepupal larvae exited mined shoots from 16 April to 7 May in MS.

Infested shoots wilt, droop, and within a few days begin to blacken (Fig. 41). Slight swellings, just below the discolored portion of the shoot, may be evident (Fig. 41). The majority of the damaged shoots wither and

break away from the plant, although a few swell and split about the gallery and remain on the plant as evidence of previous attack. Wilting and dying shoots were most conspicuous from 17 April to 15 May (MS). Damage ranged from none to severe, and on some plants, larvae killed every new shoot.

A few infested shoots were found in June, indicating that at least a partial second stem-mining generation is produced. Be-



Figs. 35–40. Pupa of *Mompha solomoni*. 35, Mandibles and labrum (ca. $\times 300$). 36, Mesothoracic spiracle (ca. $\times 300$). 37, A1–A2, dorsolateral (ca. $\times 160$). 38, A1–A2, posterodorsal (ca. $\times 150$). 39, A9–A10, dorsal (ca. $\times 150$). 40, Cremaster (ca. $\times 550$).

cause succulent, thick-stemmed new growth of *Cephalanthus* is much reduced after the spring flush, only a small percentage of the population is able to locate suitable stem tissue for larval development during the summer and fall months; most individuals

develop as leafminers through the rest of the growing season (see below).

Natural enemies issued from about 10% of the field-collected stem-mining larvae; these included three braconids (*Pholetesor* Mason, *Bracon* F. and an undescribed spe-

cies of microgastrine) and an eulophid of the genus *Euderus* Haliday. Previously recorded hosts for *Pholetesor* were all leaf-mining or shelter-feeding Lepidoptera (Whitfield and Wagner 1988). Predaceous thrips were recovered from five dissected shoots that contained dead *Mompha* larvae.

Leafmining broods of *Mompha solomoni*.—Oviposition on leaves occurs alongside the midrib or a lateral vein on the leaf undersurface, often under tufts of axillary hairs ($n = 35$). The egg texture is remarkably similar to that of the leaf surface (Figs. 45, 46). The first instar tunnels from the egg directly into the leaf blade and, in so doing, fills the eggshell with brown or black frass. The mine begins as a hair-thin sinuous track that is extended to the upper leaf surface, such that the mine is visible from both above and below (Figs. 47, 48). Some early instar mines are tortuously contorted and appear blotch-like. Early mines start adjacent to the midrib (30/54) or a secondary vein (14/54)—none were noted in the lamina away from larger veins. The larva may exit the first mine, after tunneling for 5–10 mm, and begin a new serpentine mine elsewhere, again alongside the midrib or a lateral vein. Secondary mines occasionally enter vascular tissue, staining it dark brown or black. Mine exit and reentry occurs through the lower leaf surface. Larvae feed ventral side up.

After the larva has tunneled for a distance of 10–20 mm, either a new mine is formed or the initial track is enlarged abruptly into a full depth blotch (Fig. 48). All green tissue is removed from within the blotch; in contrast to early mines, the blotch mine is often made along the leaf edge or apex (Fig. 48). The blotch mine is mostly free of frass; the sparse frass is scattered about the mine, staining both leaf surfaces, with most accumulating toward the base or one side of the mine. The mature mine is oval to round with an irregular outline and measures 10–15 × 22–31 mm ($n = 5$). The pale yellow larva turns smoky red prior to

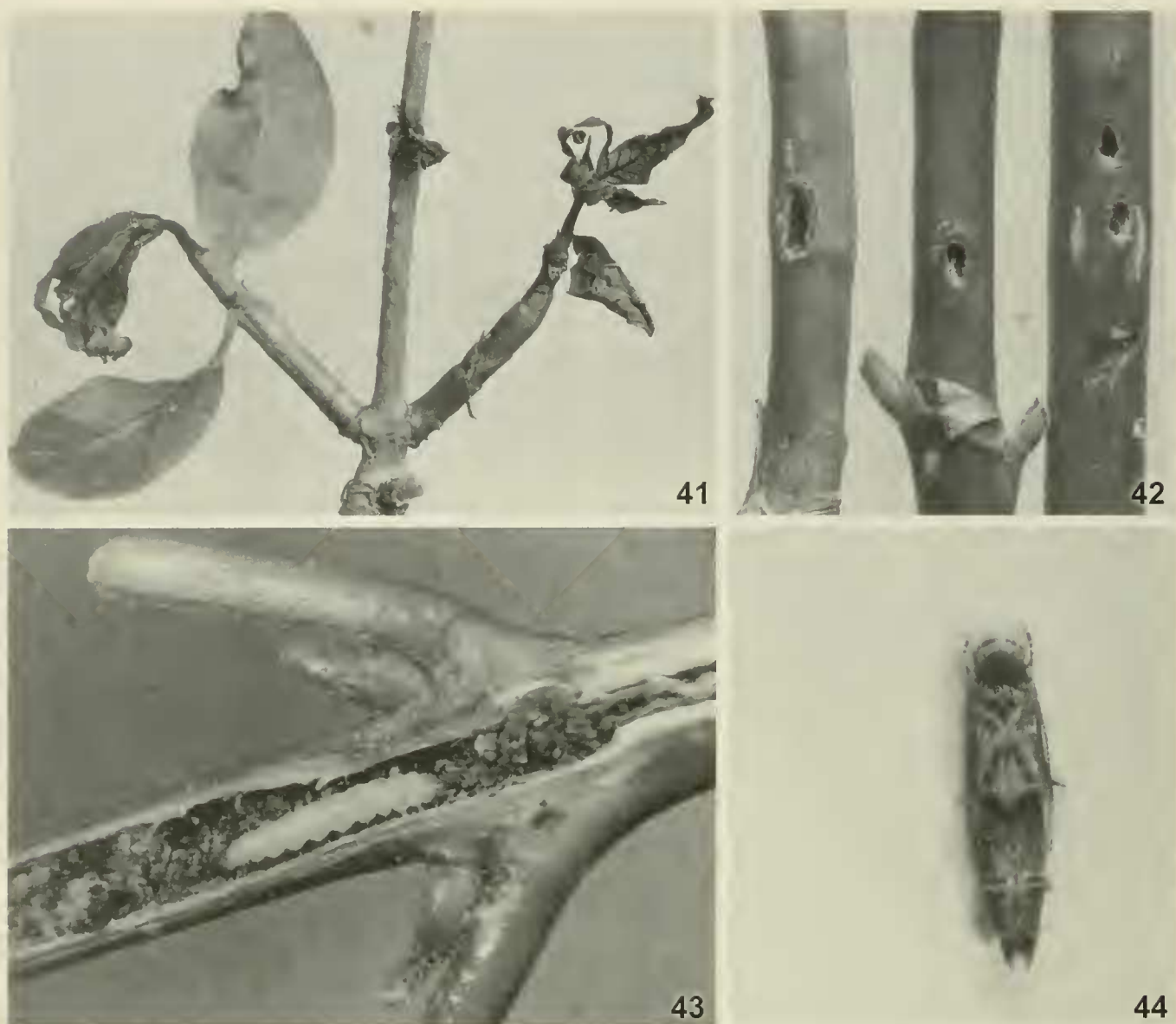
exiting the mine (Fig. 49) to pupate in leaf litter ($n = 20$).

The white cocoon (Fig. 50) is spun between overlapping leaves or in litter below the hostplant. The pupal stage during spring and summer generations lasts 12 to 14 days ($n = 30$). The majority of fall-collected larvae in New England yielded pupae that held over through the winter months, although fall-emerging adults sometimes issued from our collections made in August and as late as early September. An August lot of larvae from Hammond, NY, failed to hatch by late October, when they were placed outdoors; this same collection produced adults in May 1989. A large collection made at Thompson, CT, in early September yielded no adults that fall but more than 50 adults the following spring. Yet, another collection made the previous day nearby in Hampton, CT, produced nearly 20 adults over the ensuing five weeks (into mid October).

Our observations indicate that *M. solomoni* is multivoltine, reaching greatest abundance in late summer and early fall. Larvae and mines can be exceedingly common from August onwards, with a dozen or more mines occurring in a single leaf.

Mompha cephalonthiella.—Details of the life history are mostly unstudied. So far the species is only known to mine leaves. Five later instar mines are all full-depth mines, formed along a leaf margin (6–12 × 12–16 mm). In appearance the mines resemble those of *M. solomoni* (e.g., the two mines on the left hand side of Fig. 48). As in *M. solomoni* the mine is mostly free of frass. Both Frank Hsu (pers. comm.) and DLW have found abandoned *Mompha* mines in *Cephalanthus* in California, where *Mompha cephalonthiella* is common, with a shield-like oval cut-out at one end of the mine, reminiscent of a mine of *Antispila* Hübner (Heliozelidae).

Presumably these ovals are fashioned by the prepupal larva and are used to construct a cocoon, just as they are in the Heliozelidae. In Florida and the Neotropics an undescribed *Mompha* mines in *Hamelia pat-*

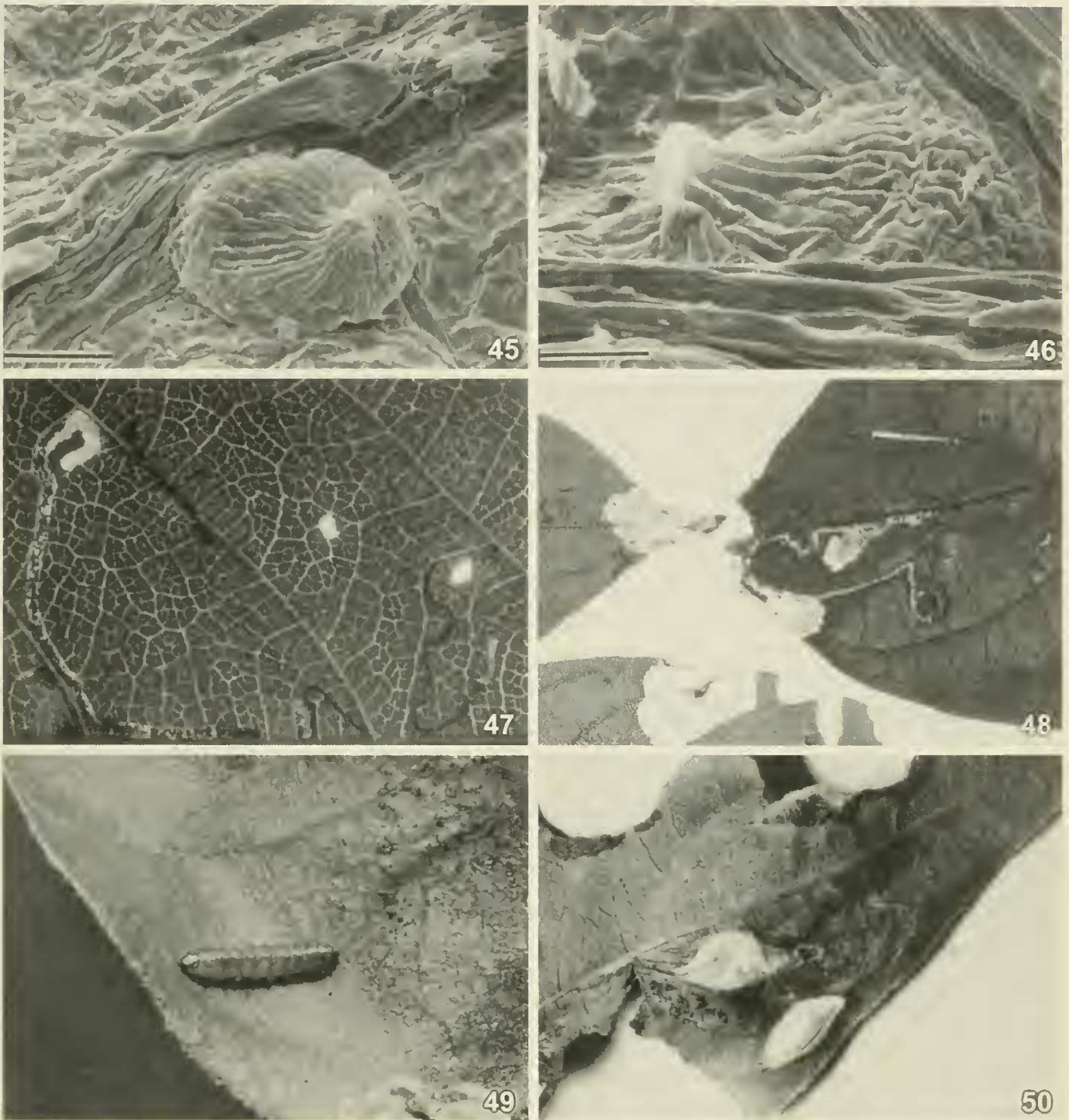


Figs. 41–44. Life history of *Mompha solomoni*. 41. Flagging leaves on mined shoots. 42. Larval exit holes at bases of mined shoots. 43. Larval gallery with loosely packed frass. 44. Adult resting posture, note raised scale tufts.

ens Jacq. (Rubiaceae). It too may cut-out an oval shield at the mine terminus. Adults of this moth are similar in appearance to those of *M. cephalonhiella* and *M. solomoni*. Chambers (1871: 222) stated that the mine of *M. cephalonhiella* resembles that of an *Antispila*, but he elaborated no further. In both Mexico and Costa Rica, DLW has reared additional momphines from melastomes whose prepupal larvae also remove oval leaf sections from the mine terminus, although their cut-outs are often more jagged than those of the Rubiaceae-feeding momphines. Busck's (1912) account of *Moriloma pardella* Busck, a momphine leafminer in *Conostegia* sp. (Melastomata-

ceae), also makes mention of this rather unusual behavior.

We have collected active mines of *Mompha cephalonhiella* from mid June (VT) through early October (CA), contradicting reports by both Chambers (1871) and Forbes (1923) that it is single-brooded. Certainly, populations reach their greatest abundance in late summer (as do those of *Mompha solomoni*). In our collections adults issued two to four weeks after the larvae were secured—with no pupae holding over to the following season, supporting the suggestion of Chambers (1871) and Forbes (1923) that this species overwinters as an adult. A March record of a flown



Figs. 45–50. Life history of *Mompha solomoni*. 45, Egg (scale = 100 μm). 46, Egg (scale = 200 μm). 47, Early instar mine. 48, Late instar full depth blotch mines [mines without dense frass packing (left and below) represent secondary mines, primary mines (right) contain considerable frass]. 49, (Reddened) prepupal larva. 50, Cocoon.

adult of *Mompha cephalonhiella* collected by Edward Knudson from Houston, Texas further supports the notion that adults overwinter.

DISCUSSION

Leafmining moths are usually highly specific in the tissues that they mine (Needham et al. 1928, Hering 1951), but mom-

phines provide numerous exceptions. The Palearctic momphines include species that switch between mining leaves and flowers or seeds, e.g., *Mompha miscella* (Dennis and Schiffermüller) (Lhomme [1948–1949]); stems and seed pods, e.g., *Mompha sturnipennella* (Treitschke) (Emmet 1982); and stems and leaves, e.g., *Mompha ochraceella* (Curtis) and *M. propinquella* (Stain-

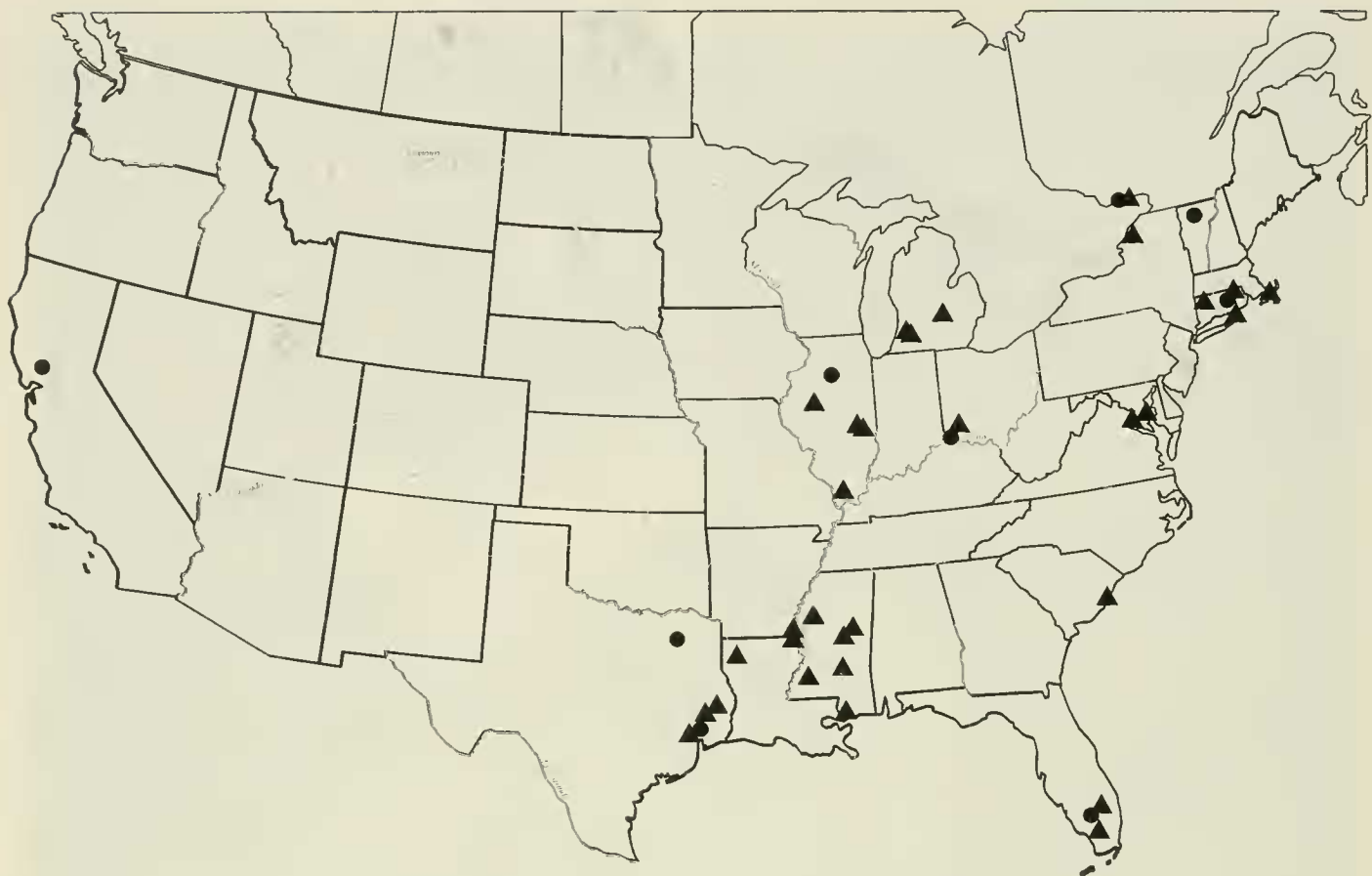


Fig. 51. Distributions of *Mompha solomoni* (triangles) and *M. cephalonhiella* (circles).

ton) (Grabe 1955, Koster 2002). In some species the changes occur during the course of development: The early instars of *M. ochraceella* mine in the bast of a stem, but later tunnel into the roots to overwinter and then return above ground to mine leaves in the spring (Koster 2002). In other *Mompha*, changes in feeding habits occur between broods, e.g., *M. miscella* was reported by Lhomme [1948–1949] to mine leaves in the spring and flowers or seeds in the second generation. The mining habits of *Mompha solomoni*, involving a switch from shoot mining in the spring to leaf mining in the summer and fall, initially seemed exceptional to us; however, this change is not so improbable given the variation displayed by Palearctic species. The similarity of scaling characters and genitalia of the shoot boring and leafmining generations suggests that the two represent but a single species.

The new species appears to be a member of a species group that includes *Mompha cephalonhiella* and additional undescribed species, at least one of which is a leafminer

in another member of the Rubiaceae, *Hamelia patens*. DLW has made collections of this moth in both southern Florida and Costa Rica. Other undescribed taxa that may be members of this species cluster were found among unsorted Floridian momphines in the USNM. Given the phenotypic similarity of the imagoes, the group's members exhibit marked biological differences, e.g., *Mompha cephalonhiella* is thought to overwinter as an adult and *M. solomoni* as a pupa. *M. cephalonhiella* and the *Hamelia*-feeder may fashion an oval cut-out or shield from the mine terminus, in the same manner as is done by heliozelids; *M. solomoni* simply drops into leaf litter to make its cocoon. (Curiously, the shield-making behavior appears to be facultative in both *M. cephalonhiella* and the new species from *Hamelia*.)

While many authors have recognized the importance of Onagraceae in temperate radiations of the Momphinae (Forbes 1923, Powell 1980, Stehr 1987, Scoble 1992, Hodges 1998, Powell et al. 1998), few have

mentioned Rubiaceae as a host family for momphines. We know of five North American species associated with Rubiaceae (the two on *Cephalanthus* treated here and three undescribed species: on *Galium*, *Hamelia*, and *Spermacoce*). Given our present understanding of the biologies of the North American momphines, which is admittedly incomplete, the Rubiaceae rank third in their importance as larval hosts for Momphinae, behind the Onagraceae and Cistaceae (DLW unpublished data; T. Harrison in litt.). Given the presence of momphines in Central America and the great diversity of Rubiaceae in low latitudes, we think it likely that many other (undescribed) species will be found to be associated with this family.

L group is bisetose on T1 (Fig. 22)—a condition unique to the momphines among all Gelechioidea (Stehr 1987, Hodges 1998). Larvae of *Mompha solomoni* possess a pair of flattened setae below each tarsal claw (Fig. 27), a feature present in many but not all momphines (Hodges 1998). Mosher (1916) claimed that the frontocylpeal suture was present in momphids; our preparation of the pupa of *M. solomoni* (Fig. 35) lacked the suture. One of the most curious features separating the two button-bush-feeding species is the development of the lateral oval pockets that open toward the caudal end of A7 in females of *Mompha solomoni* (Fig. 7) and *M. cephalonthiella* (Fig. 8). These pockets are more pronounced in *M. cephalonthiella* than in *M. solomoni*. Their function is unknown; perhaps they receive the valvae during copulation or are in some way involved in pheromone release. Evidently, these pockets are widespread among momphines (John Wilterding, personal communication).

Additional taxonomic and biological work is needed. It would be helpful to document that the spring-active, stem-mining individuals do, in fact, give rise to the summer-active leafmining generations. Stated differently, confirmation is needed that *Mompha solomoni* is a single species, and

not two closely allied cryptic species, one of which mines only in new shoots. Are *Mompha solomoni* and *M. cephalonthiella* sister taxa or do they represent different sections of a Rubiaceae-feeding clade of momphines? Is either species capable of overwintering as both pupae and adults, or is the overwintering stage a defining trait for each of these moths?

ACKNOWLEDGMENTS

James Solomon provided numerous collections of *Mompha solomoni*, as well as biological notes and photographs (Figs. 41–44). Ron Hodges, Jadranka Rota, and John Wilterding made numerous suggestions that improved the manuscript. Terry Harrison shared his personal observations with us and offered numerous helpful suggestions on an earlier version of the manuscript. Specimens were loaned by George Balogh, Terry Harrison, Edward Knudson, Bernard Landry, Jean-Francois Landry, and James Wiker. Shawn Kennedy assisted with the preparation and labeling of the figures. John Steiner, Office for Imaging and Photographic Services, Smithsonian Institution, provided the images of adult *Mompha solomoni* and *M. cephalonthiella*. Virge Kask helped with the distribution map and Figure 1. Support for this research was provided by NSF (BSR-9007671) to DLW, the Department of Systematic Biology to DA, and NSF (DEB-9200856), Mississippi Agricultural and Forestry Station, and Mississippi Natural Heritage Program to RLB.

LITERATURE CITED

- Busck, A. 1912. Descriptions of new genera and species of microlepidoptera from Panama. *Smithsonian Miscellaneous Collections* 59: 1–10.
- Chambers, V. T. 1871. Micro-lepidoptera. *Canadian Entomologist* 3: 221–224.
- Clarke, J. F. G. 1941. The preparation of slides of the genitalia of Lepidoptera. *Bulletin of the Brooklyn Entomological Society* 36: 149–161.
- Emmet, A. M. 1982. Notes on *Mompha nodicolella* Fuchs (Lep.: Momphidae). *Entomologist's Record and Journal of Variation* 94: 21–24.
- Forbes, W. T. M. 1923. The Lepidoptera of New York and Neighboring States. *Primitive Forms, Micro-*

- lepidoptera, Pyraloids, Bombyces. Cornell University Agricultural Experiment Station Memoir 68. 729 pp.
- Grabe, A. 1955. Kleinschmetterlinge des Ruhrgebietes. Mitteilungen aus des Ruhrlandmuseums der Stadt Essen 177: 1–159.
- Hering, E. M. 1951. Biology of the Leaf Miners. Dr. W. Junk, s'Gravenhage, Netherlands. 420 pp.
- Hodges, R. W. 1992. Two new species of *Mompha* from California (Lepidoptera: Momphidae). Journal of the New York Entomological Society 100: 203–208.
- . 1998. The Gelechioidea. pp. 131–158. In Kristensen, N. P., ed. Lepidoptera, Moths, and Butterflies. Volume 1: Evolution, Systematics, and Biogeography. Handbook for Zoology, Volume IV. Arthropoda: Insecta. Walter de Gruyter, Berlin, Germany. 491 pp.
- Hodges, R. W. et al., eds. 1983. Checklist of the Lepidoptera of America North of Mexico. E.W. Classey and Wedge Entomological Research Foundation, London, England, 284 pp.
- Kornerup, A. and J. H. Wanscher. 1978. Methuen Handbook of Colour. Third Ed. Methuen and Company, Ltd., London. 252 pp.
- Koster, J. C. 2002. Momphidae. pp. 224–254. In Emmet, A. M. and J. R. Langmaid, eds. The Moths and Butterflies of Great Britain and Ireland, Harley, Martins, England.
- Lhomme, L., [1948–1949]. Cosmopterygidae. pp. 677–699. In Lhomme, L., 1935–[1963]. Catalogue des Lépidoptères de France et de Belgique. 2. Microlépidoptères. Le Carriol, Douelle (Lot), France, 1253 pp.
- Mosher, E. 1916. A classification of the Lepidoptera based on characters of the pupa. Bulletin of the Illinois State Laboratory of Natural History 12: 15–159.
- Needham, J. G., S. W. Frost, and B. H. Hill. 1928. Leaf-mining Insects. Williams and Wilkins, Baltimore, Maryland. 351 pp.
- Poole, R. W. and P. Gentili, eds. 1996. Nomina Insecta Nearctica. Volume 3. Diptera, Lepidoptera, Siphonaptera. Entomological Information Services, Rockville, Maryland, 1143 pp.
- Powell, J. A. 1980. Evolution of larval food preferences in microlépidoptera. Annual Review of Entomology 25: 133–159.
- Powell, J. A., C. Mitter, and B. Farrell. 1998. Evolution of larval food preferences in Lepidoptera. pp. 403–422. In Kristensen, N. P., ed. Lepidoptera, Moths, and Butterflies. Volume 1: Evolution, Systematics, and Biogeography. Handbook for Zoology, Volume IV. Arthropoda: Insecta. Walter de Gruyter, Berlin. 491 pp.
- Scoble, M. J. 1992. The Lepidoptera. Form, Function, and Diversity. Oxford University Press, Oxford. 404 pp.
- Stehr, F. W. 1987. Momphidae. p. 389. In Stehr, F. W., ed. Immature Insects. Kendall-Hunt, Dubuque, Iowa. 754 pp.
- Whitfield, J. B. and D. L. Wagner. 1988. Patterns and host ranges within the parasitoid genus *Pholetesor* Mason (Hymenoptera: Braconidae). Environmental Entomology 17: 608–615.